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ENTOMOLOGY IN THE PEOPLE'S REPUBLIC OF CHINA[1]

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Introduction

China is one of the oldest civilizations in the world. The span of Chinese history is the evolution from half-million-year old Peking-Man to 20th Cen-

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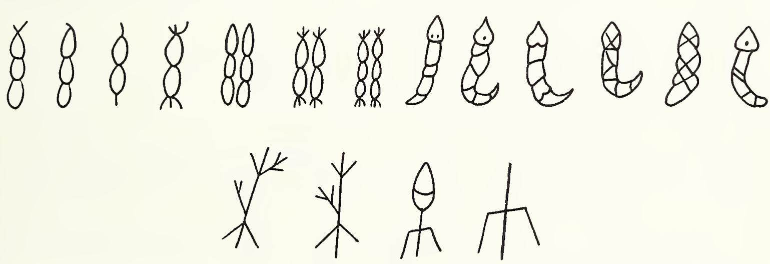
tury technologists. The earliest evidence of Chinese civilization and science development provided by a series of archaeological findings is set at more than 5,000 years ago. Under successive dynasties Chinese achievements in literature, philosophy, art, and certain fields of science are among the highest in the world. However, the advent of Western technologies at the turn of 19th Century had profound consequences for traditional China. In order to accommodate with the outside world, China has gone through drastic changes in political, economic, and scientific systems. As with other sciences in China, entomology has evolved and reached to a level of glorious attainment in the history. It would be highly inappropriate for anyone to discuss the current entomology in The People's Republic of China (PRC) without knowing the history of Chinese entomology.

I. Development of Entomological Studies

A. Historical Overview of China's Entomology

a. Study of beneficial insects.—Silkworm (*Bombyx mori* L.) (Lepidoptera: Bombycidae): Sericulture and silk technology date back to the period of Agriculture ca. 4,500–7,000 years ago, as evidenced by the recent discovery of a Neolithic relic site in Zhejiang Province (Map 1), where the silk material along with rice seeds unearthed were determined by C^{14} dating method to be 4,728 ± 100 years old (Anonymous 1980; Chou 1980). The silk technology advanced further in Yin Dynasty (16th–11th Century B.C.) as the silk cloth unearthed from the Yin tombs revealed both flat and in relief patterns. During this period, the tortoiseshells used as paper were found inscribed with the idiograms



denoting the characters silk, silkworm and mulberry tree respectively (Chou 1980). The mass planting of mulberry and indoor rearing of silkworm were recorded in the Xia Dynasty (1711 B.C.) (Anonymous 1980; Chou 1980). By the 9th Century, as a result of continuous breeding and rearing of the silkworm, many books on the bionomics of this insect had been published. The technique for storing the eggs of silkworm in low temperatures was developed in the 4th Century A.D. The domesticated silkworm, *B. mori* is thought to be evolved from the wild species *B. mandarina* (Moore) (Chou 1980). The silk road was built 138–126 B.C. in Han Dynasty, but the records showed that the technology of sericulture was not introduced in Turkey until the 6th Century A.D. It was introduced into Korea as early as the 12th Century B.C. Because of geographical barriers its introduction into Japan came as late as the 2nd Century A.D.

Other silk producing insects have also been utilized in China since the 12th Century B.C. The breeding of the other silkworms, *Antherea pernyi* Guerin started in the 1st Century A.D.; and *Semia cynthia pryeri* Butler, and *Eriogyma pyretorum* (Westw.) in the 17th Century A.D.

Honeybee (*Apis cerana* Fab.) (Hymenoptera: Apidae): The history of apiculture is as old as sericulture in China. The tortoiseshells found in the Yin tombs bore the inscriptions of the idiograms of bee (Chou 1980).

The commercial breeding and the teaching of beekeeping prospered 1,800 years ago (Anonymous 1980). The uses of beeswax for candles and pills were known in the 7th Century A.D. Several monographs dealing with bee morphology, biology, rearing techniques, social behavior, control of natural enemies, honey extraction, and apiary management were published during the period of 1273–1817 A.D.

Wax insect (*Ericerus pela* Chav.) (Homoptera: Coccidae): The wax of this scale insect was first utilized in China in 1300 B.C. In the next two centuries, a great deal of information on its host ranges, distribution, biology, and methods of extracting wax was published.

Lac (*Laccifer lacca* Kern) (Homoptera: Lacciferidae): During the 3rd Century A.D., the Chinese were first to describe methods of distributing the immatures of *L. lacca* on the tree in order to produce the lac which was used for dye, lacquer, and medicine (Anonymous 1980; Chou 1980).

Gall insect (*Melaphis chinensis* Walsh.) (Homoptera: Eriosomatidae): As early as the 1st Century B.C. the leaf galls produced by *M. chinensis* were used for extracting tannin which has been used in dye and medicine (Anonymous 1980; Chou 1980).

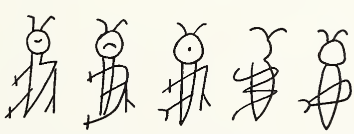
Insects as medicine: From 31 B.C. to 1578 A.D. a total of 73 species of insects had been listed in Chinese medical publication entitled "Compendium Materia Medica." Several common insects are currently used in Chinese medicine: the exuviae of cicadas are used against fever. Tannin extracted from the leaf galls of *M. chinensis* is an astringent compound. Cantharadin from the blister beetles, *Lytta caraganae* Pallas, *Myabris phalerata* Pallas, and *Epicauta* spp., is used as a cure for ulcers and as a abortion agent. The egg cases of mantid are used for curing impotence. Silkworms infected with muscardine fungus, *Metarrhizium anisopliae* Metsch, are used as a cure for palpitation. Lepidopterous larvae parasitized by *Cordyces* sp. fungus are used as a cough medicine, and the bee sting is used for treating arthritis (Anonymous 1980; Chou 1980).

Edible insects: Historical records showed that men ate the larvae and pupae of bees and wasps, the nymphs of cicadas, and the immatures of ants in 1200 B.C. Locusts as food were recorded in 23 A.D. Currently the pupae of silkworm and giant silkworm and the predaceous diving beetles (*Cybister* spp.) are still being used as food by some people in China.

Insects used for other purpose: Insects have become the main theme in numerous poems and paintings throughout Chinese history. May beetles and buprestids were used as ornamentals in the 11th Century A.D. During 618–905 A.D., cicadas and crickets were bred for song contests. Since then several species of crickets (*Scapsipedus aspersus* (Walker), *Homoeogryllus japonicus* (Haän), *Gryllus testaceus* Walker, and *Brachytrupes portentosus* L.) were bred for fighting contests. As a consequence there were at least five monographs dealing with cricket identification, food preference, biology, fighting techniques, and artificial rearing techniques published during 1265–1884 A.D.

b. Study of agricultural pests.—China has been an agricultural society for more than 5,000 years. Undoubtedly, China has a long history of fighting against various agricultural pests. A book written in the 11th Century B.C., entitled "Book of Poems" which dealt with a number of agricultural subjects described the decree issued by the ancient ruler to mobilize peasants in insect control, and to recommend insect control with fire. A pest control officer was officially installed in Zhou Dynasty (ca. 240 B.C.). During this period a series of control measures were employed such as the use of heat, lime, plant ashes and insecticidal plants (Chou 1980).

Locusts (*Locusta migratoria* L.): The locust problem has plagued Chinese agriculture for as long as Chinese history is dated. Probably it has evolved with the cultivated crops, mainly Gramineae, for about 6,000 years. The earliest evidence of locust and man association was found in the Yin Dynasty. The tortoiseshells found in the Yin tombs have a number of idiograms



representing the character "locust." The first antilocust decree was issued in 29 A.D. (Chou 1980). During the period of 707 B.C. to 1911 A.D., between 538 and 800 locust outbreaks were recorded (Anonymous 1977a; Chou 1980). Since the 17th Century A.D. a number of publications have appeared concerning the breeding sites, host ranges, morphology, biology, ecology, gregarious and migratory behaviors, and control measures of this insect.

Lepidopterous insects: Stemborers (*Diatraea verosata* Walker, *D. shariinensis* Eguchi, *Chilo simplex* Butler) are currently considered to be the second most important pests of graminaceous crops. Between 718 B.C. and 1911 A.D. about 50 serious outbreaks were recorded (Chou 1980). Army worm (*Leucania separata* Walk.) had 49 outbreaks between 500–1700 A.D.

Other insects such as wild silkworm (*Bombyx mandarina* Moore), mulberry geometrid, (*Hemerophila atrilineata* Butler), angoumois grain moth (*Sitotroga cerealella* Oliv.), black mulberry beetle (*Chrysochus chinensis* Baly.), wheat midge (*Sitodiplosis mosellana* Gehin), and the cricket (*Gryllus* spp.) were reported for a number of outbreaks during the period of 26–1839 A.D.

c. Insect control measures.—Physical control: The manual control of insects was first described 1,800 years ago, the control of silver fish *Ctenolepisma* (*Lepisma*) *vilosa* (Fabricius) was recorded 2,000 years ago. The use of fire to control insects was recorded about 240 B.C. (Anonymous 1979).

Cultural control: Weeding and deep plowing were employed to control insects in 239 B.C. Varying dates of planting and harvesting which played an important role in reducing the insect pests were reported during 528–549 A.D. Other practices such as crop rotation, irrigation, and the use of resistant variety were also recorded in the history.

Biological control: This practice has been used in China since 304 A.D. The classic example is the use of predaceous ants (*Oecophylla smaragdina* F.) to control a number of citrus pests such as leaf beetles, curculioes, scarabaeus beetles, and stink bugs (Anonymous 1980). The use of ducks to control pests in paddy field dates back to the period of 1611–1672 A.D. The decree was issued by the ruler of Late Han Dynasty (948–980 A.D.) to protect such insect predators as birds and frogs.

Chemical control: The use of plant ashes and lime to control the household insects has been known for over 3,000 years. Mercury used for flea control and the treatment of wheat seeds with arsenic for control of underground insects were reported 2,000 years ago. Other organic compounds such as aluminum and copper for flea control and sulfur for control of ornamental insects were reported 1,000–1,500 years ago (Anonymous 1980; Chou 1980).

The use of a variety of insecticidal plants including *Zingiber mioga,* and *Illicium lanceolatum* to control medical and storage insects was recorded 3,000 years ago. Other plants with insecticidal activities were: *Aconitum lycactorum, A. fischeri, Daphne genkwa, Chaenomeles sinensis, Ligusticum sinensis, Artemisia scoparia, Incarvillea sinensis, Celastrus* sp., *Croton* sp., *Ruta* sp., *Stemona* sp., *Xanthium* sp., *Spirodela* sp., *Gleditsia* sp. They were used during 1000 B.C. to 1700 A.D. (Chou 1980).

d. Study of insect morphology and biology.—The earliest record of studying insect morphology came in 250 B.C. when the Chinese described the exoskeleton and endoskeleton of the insects. The morphological characteristics of the planthopper, *Lycorma delicatula* white, and the louse fly, *Hyppobosca capensis* Olfers were described in detail in 1116 and 1578 A.D. respectively (Anonymous 1980; Chou 1980). At the same time, the phenomenon of metamorphosis in mantids was reported. Later the metamorphosis of Lepidoptera (butterflies and moths) and caddisflies was reported in 300 and 739 A.D. respectively. The parthenogenesis of insect was recorded in 600 B.C. Color mimicry was first described in the 1st Century A.D.

The relationship between the prey and predator was first studied in 502 A.D. with sphecid wasps (including the members of Eumenidae, Sphecidae, Trypoxylidae) carrying the borer larvae to their nests as food for their young (Anonymous 1977a; Chou 1980). During the 7th Century it was reported that not only the borer larvae but also spiders were used as food for the young, and that the eggs of wasps were deposited on the prey. Others reported that tachinid flies parasitized on the silkworms in the 15th Century A.D. (Chou 1980).

B. The Influence of Western Industrial Revolution in the 19th and 20th Centuries

Although China has a glorious ancient history of science and civilization, it was only at the turn of the 19th Century that the study of entomology as part of plant protection was initiated as a modern scientific discipline. China is a country built on agriculture, and will probably remain an agricultural nation from some time to come. This is basically due to the fact that the country covers an area of 9,6000,000 km^2 (=3,706,000 mi^2), and the current population is about 1 billion. Two-thirds of the total area is mountainous or semidesert; only 11% of the land is arable. Nearly 90% of the population is concentrated on the fertile plains and deltas of the east which accounts for $^1/_6$ of the land. Geographically speaking, the country is in the Temperate Zone with the exceptions of the southern portions of the country including Yunan, Guangdong, and Guangxi Provinces which are within the Tropics. Therefore, agriculture which provides enough foods and clothes has become the major theme for every dynasty in Chinese history.

The industrial revolution and Western expansionism of the 19th Century has brought China a series of military and political humiliations. Realizing the inability of the old agricultural system in dealing either with internal difficulties or with foreign encroachments, China started a series of reforms in a society structured by about 5,000 years of civilization. Since then, China has been repeatedly subjected to political, economic and intellectual chaos and revolutions in order to accommodate with the modern world. Like most other disciplines of science, entomology, in the broader field of plant protection, has gone through many phases of changes. A systematic study of entomological science started in 1911. During the period of 1922–1924, a Bureau of Entomology was first established in Jiangsu and Zhejiang Provinces. The entomologists in these two organizations engaged in the systematic study of the major agricultural pests, and medical insects in southern China. The first "Year Book of the Bureau of Entomology" and "Insects and Plant Diseases" were both published by the Bureau of Entomology in Zhejiang Province. Meanwhile they also had trained several scores of entomologists who were later assigned to other provinces. Immediately after 1924, an Entomological Institute similar to the Bureau of Entomology was formally established in Hunan, Jiangxi, Guangdong, and Sichuan Provinces. Several universities and colleges had established a Department of Plant Pathology and Entomology, or Division of Entomology. At the same time, formal teaching and research in entomology were instituted in the colleges and universities. The prestigious Chinese Academy of Sciences (CAS) was formed in 1930. Courses in entomology were included in the curriculum of the Department of Agricultural Zoology in the comprehensive universities and agricultural colleges.

Plant protection science in general suffered a lot from the impact of World War I, and internally, China was all but shattered in the era of warlords. Then came World War II. Most of the research institutes and universities were forced to evacuate to the interior during the war, and very little progress was made in the field of entomology during the 1940's. In spite of the difficult situation during the war, a number of institutions maintained or re-established a Department of Plant Pathology and Entomology usually in their Colleges of Agriculture. Students in their junior and senior years would specialize in either entomology or plant pathology, even though their degree was awarded by the same department. Only Beijing University and Qinghua University had established an independent Department of Entomology in their College of Agriculture during the period 1945–1949.

C. The Era of 1950's

After the founding of the People's Republic of China in 1949, the country enjoyed steady growth for a decade. The leaders of PRC had transformed a weak and backward China into a strong and modern state. The progress of Chinese economy and science in the years of rehabilitation following 1949 was very impressive. In 1953, the "First Five-Year Plan" was initiated in PRC with emphasis on national defense and heavy industry. The economy was basically still agrarian, with a small modern industry concentrated in the northeast and east coast. Even though agriculture produced a greater share of the GNP in this period, it still received little investment from the state. Progress continued until the experiments of the "Great Leap Forward"

(1958–1960) which featured backyard steel plants plunged China into a depression in the early 1960's.

Several outstanding accomplishments can be cited in this golden period. In 1949, there were 450 million people in PRC with an average of less than two years of education per capita. In a decade, the school enrollments quadrupled reaching 100 million and the average number of years of education rose to 3.5 years per capita. Enrollment in primary school was compulsory, therefore it became universal, and junior high enrollment was nearly universal in the cities and surrounding rural areas. The senior high and college enrollments were rather restricted due to lack of facilities and there was extreme competition for admission to these two levels. The Western schooling in China taking roots in this period was mainly due to the earlier influences of foreigners such as American, British, German, French and Japanese in China before the liberation, and the influence of more than 30,000 Chinese educated abroad. Immediately after the liberation, education was totally taken out of foreign hands.

In 1954, higher education was reorganized and modelled on the Soviet system, which emphasized science and technology and the topical specialization of institutions. As a consequence, separate Departments of Plant Pathology and Departments of Entomology were combined into one Department of Plant Protection. There were only two major courses in entomology taught at college: General Entomology and Agricultural Entomology. The former included morphology, anatomy, physiology, life history, ecology and taxonomy. Under this system, no elective courses were offered at colleges and the credit system was also abolished. The comprehensive universities became the main sources to train college faculty. The graduate program was also reorganized on the Soviet model. Roughly 16,000 students were trained by Chinese institutions at the graduate level during 1955–1965. In the same period, approximately 3,000 other Chinese students were trained at the graduate level in USSR and Eastern European nations.

The Institute of Entomology was first established in 1950 under the administration of CAS followed by the establishment of an Institute of Entomology in several localities under the administration of different city and provincial governments. Similarly, the Institute of Plant Protection was also established in several places under the jurisdiction of the Chinese Academy of Agricultural Sciences (CAAS) as well as city and provincial governments. Besides the expansion of various research institutions as mentioned above, there were noted accomplishments in the educational field. Courses in entomology and plant protection were offered in the Biology Department of the comprehensive universities and the College of Forestry respectively. In Central Government, the Bureau of Plant Protection was formed under the Ministry of Agriculture. Consequently, the Plant Protection and Inspection Stations functioned under various city and provincial governments. Plant Quarantine

Stations were set up at the major ports by the Foreign Trade Department. At the same time, medical entomology received a great deal of attention; several research institutes of medical entomology were brought into the picture by the Health Department.

During the period 1953–1957, most of the China's trained entomologists were brought into the CAS, and its affiliated research institutes. The CAS served as the focal point for planning and conducting research on a national scale. The Institute of Entomology served as the center of all entomological activities throughout the land. By decree of Mao Zedong, all scientific research had to point toward practical application. Therefore, the entomological publications during this era dealt, by and large, with applied research. Nonetheless, some basic research of high quality was published by Chinese entomologists trained abroad.

The first issue of "Acta Entomologica Sinica" and that of "Bulletin of Entomological Society of China" were published in 1951 by the Entomological Society of China. The latter was renamed "Kunchong Zhishi" (="Knowledge of Insects") in 1955. A total of 10 volumes of "Journal of Economic Entomology" was published in the 1950's. The Entomological Society of China grew from 861 members in 1954 to 1,068 in 1958 with 22 branches throughout the country (Yueh 1958). By 1963, the number of institutions of higher learning had doubled to 400 as compared to 1949, with the enrollment up from 117,000 to 819,000 (Cheng 1963). Both undergraduate and graduate training in entomology were offered by most of the 50 comprehensive universities and agricultural institutes. A monograph on the standardization of entomological nomenclature was published in 1956 containing a comprehensive list of the names of insects in Chinese and in Latin names (Anonymous 1956).

D. Pre-Cultural Revolution Period (1960–1966)

In 1962, the Plant Protection Society of China was installed and its official publication "Acta Phytophylacica Sinica" was issued subsequently. The following year a sister journal entitled "Zhiwu Baohu" (="Plant Protection") was published to accommodate the influx of manuscripts submitted to the society. During the period of 1962–1965, the Beijing Agricultural University and Nanjing Agricultural College were designated as two "Key" institutions by the Ministry of Education, specifically to train the college faculty and researchers in the field of plant protection. The college curriculum was five years with the additional year devoted to studying such entomological courses as taxonomy, physiology, toxicology, ecology, and forecasting. In the last year, the students were allowed to either specialize in plant pathology or entomology. But this 5-year college curriculum was reduced to four years a year before the onset of Cultural Revolution.

The average number of school years reached 5.5 per capita in the pre-Cultural Revolution period. As a consequence, a flood of graduates entered the labor markets seeking the city and industrial jobs, and met with disappointment. Meanwhile, the gaps between the better educated and the less educated, and the cities and the rural areas continued to widen. The leadership in PRC considered that these trends were very unhealthy. Thus the government instituted the initial program of sending millions of youths down to the country-side (Xiafang) in order to alleviate the tension and to increase the manpower in rural areas.

E. Cultural Revolution Period (1966–1976)

In subsequent years, the full scale Cultural Revolution was carried out which resulted in major changes in Chinese education and virtually all sectors of Chinese society. The "Xiafang" movement was intensified as millions of young people who had been enrolled in the school were sent to the rural areas in order to emphasize learning through practice. Text books and curricula were designed to emphasize the needs of the area in which each institution is located, especially if the subject is agriculture production. All middle school graduates were required to work in the factories or on farms for at least 2 years before applying for a recommendation to attend colleges. Higher education was especially a prime target of attack, colleges and universities were completely closed for a period of about five years. From 1966 to 1978 graduate school training was indeed nonexistent. At the onset of Cultural Revolution there were 100 research institutes, but that was reduced to only 40 in 1976. By this time, China had only 1.2 million scientists, engineers and technicians, less than 1% of the total population. When schools reopened in 1970, the students were recruited for colleges solely on the basis of applicant's political record and family-class background instead of academic excellence. In the early 1970's, college curricula were redesigned to meet needs of production, they were shortened to three or two years, from five years previously. Similarly the primary and secondary school curricula were also reduced from six to five years each. No school records were kept during the cultural revolution period.

It should, however, be noted that a great deal of applied research was carried out during this period (Guyer 1977), and that some of the students even though they were not selected on the base of academic excellence, were indeed intellectually talented. Most of the practical publications that appeared in this period were prepared by and credited to the editorial committee instead of individual researchers. The editorial committee consisted of producers, scientists, and administrators. Thus information in the publication met practical needs and was technically sound, and the measures recommended were also administratively feasible (Chiang 1977a).

The achievements in agriculture were impressive. The PRC was able to attain a self-sufficiency in foods even though its population was enormous and growing. During this period, the policy called for self-reliance at all levels, from the top of government to small communes. The chief reason for the success is in the intensive and efficient use of land through multiple cropping and intercropping along with good water and soil management practices, and resistant variety development. But multiple cropping and intercropping systems led to complicated plant protection methods.

F. Post Cultural Revolution Era

Since 1976, educational policy has returned to a pre-Cultural Revolution era committed to academic excellence. The examination system has been reintroduced in the schools. High school graduates are no longer required to work before entering the colleges. Because of a shortage of colleges and universities, the competition in entrance examination remains very keen. Thus only those who are well qualified academically as well as politically, will be admitted to the colleges. To date, college curricula have been lengthened to four years. In 1977 four modernization programs were initiated, they include agriculture, industry, defense, and science and technology. It was since further affirmed that top investment priority is given to the modernization of agriculture and science and technology (Reardon-Anderson 1978). The training in the secondary schools is heavily oriented toward the natural sciences and mathematics. Foreign languages begins in the primary schools and continues through middle school. The research activities for faculty and student are now evident, and research facilities are being rapidly procured and upgraded.

The current higher education in PRC can best be characterized as follows: Since 1949, education is considered to be a major governmental responsibility and a public enterprise. As in many socialist states, a private educational system is practically non-existent in PRC. The struggle for technological development and modernization in education is seen as a vital factor to enable China to establish and maintain a position of importance in the world. It is clear that science and technology are perceived as the fundamental features of the modern education. However, the emphasis is placed on applied science and technology rather than basic sciences.

II. Development of Control Methods

In the 1950's chemical control played the predominant role in China's struggle against such insect pests as migratory locusts, corn borers, sugar cane borers, rice stem borers, wheat midges, armyworms, cotton bollworms, pine caterpillars, mites, spiders, and medical insects. During the period of

1953–1957, a total of 170,000 tons of insecticides was used on the cultivated land, and about 6 million hectares of crops which covered 70% of infested areas were treated for locust control by aerial dusting. In 1958 alone, an average of 14.7 kg of indigenous insecticides per hectare was used on various crops (Chiu 1959). Benzene hexachloride (BHC), DDT, and other organic phosphorous compounds such as DDVP, malathion, Dipterex and Demeton were the main pesticides used for control of major pests throughout China.

The use of native plant and mineral products as a supplement to the imported insecticides was actively encouraged in 1958, about 500 native products were made into 10 million tons of insecticides and fungicides (Chiu 1959). Two *Derris* spp. containing 13.5 and 10% rotenone and one nicotine-bearing species, *Anabasis aphylla* were found and utilized (Cheng 1963).

The successful examples of using biological control were numerous in the 1950's. The use of parasitic wasps, *Trichogramma* spp. for sugarcane borer control in Guangdong and Guangxi Provinces was highly successful. By 1959, nearly 5,500 hectares of sugarcane plantations were under this control program as compared to 480 hectares in the previous year. As a result of biological control, the sugarcane yield increased by about ⅓ (Pu et al. 1956). Another noteworthy development in biological control was the rearing techniques for *Trichogramma* spp. and their biology study. It was found that the wasps reared on the eggs of pine caterpillar and ricinus silkworm were larger in size, more active, with a higher fecundity, and higher ♀ : ♂ ratio than those raised on angoumois grain moth, *Sitotroga cerealella* Oliv. The eggs of the hosts could be stored up to 2–3 months at 4°–0°C respectively without ill effect on parasite rearing. The adult wasps fed on a honey diet lived 8.6 times longer and produced 14.7 times more than those reared on distilled water.

Other examples of biological control were equally successful including the use of *Dibrachys cavus* Wilk. against the pink bollworm, the tachinid fly, *Zenillia roseanae* B. B. against the rice leaf roller, the rice swarming caterpillar and the European corn borer (Yang 1958), the lady beetles, *Rodolia cardinalis* Mulsant and *R. rufopilosa* Mulsant against cottony cushion scales (Chiu 1959). The muscardine fungus, *Beauveria bassiana* was reported to be used against the soybean pod borer, the sweet potato weevil, and the pine caterpillar (Hsu et al. 1959; Lin 1956).

In addition to chemical and biological control measures, other means of insect control were reportedly employed with limited success. Early or late sowing and transplanting of rice resulted in less borer damages (Chiu 1959). Similarly, late sowing of wheat was reported to reduce the damage by wheat stem maggot, *Meromyza saltatrix* L. in Shaanxi Province. The removal of the weed, *Leersia hexandra* Swartz from the paddy fields was an effective control of the rice gall-midge, *Pachydiplosis oryzae* Wood-Mason and the planthopper, *Nilaparvata lugens* Stål. The method of drowning the rice borer, *Tryporyza* (=*Schoenobius*) *incertulas* (Walker) was practiced over a large area (Chiu 1959).

In the 1950's the age-old problem of migratory locust, *Locusta migratoria manilensis* was effectively controlled by sophisticated environmental control techniques. The problems were managed through installation of reservoirs and drainage systems, transformation of water-logged areas, reclamation of wastelands along the coast, and elimination of particular breeding habitats such as lake shore, flooded plain, coastal areas, and river flooded areas (Ma 1958, 1962). An excellent example is that in a decade (1950–1960), a total of 15,492 km of irrigation systems were built. As a consequence, 39,000 hectares were under flood control, and 370,500 hectares were placed under irrigation system in Shangdong Province alone (Guyer 1977).

The system of monitoring and forecasting insect population became an integral part of pest management in China (Anonymous 1977a, b, 1979b): the program started in 1951 and by 1958 a total of 678 insect monitoring and forecasting stations was in operation throughout the nation, with 700,000 farmers participating in the program (Su 1959). These stations were mostly limited to short-range forecasting of insect outbreaks in large rural areas. However, the information obtained from the study of population dynamics of migratory locusts made long range forecasting possible.

The pests of major crops and their control measures are cited below.

1. Rice insects: China is the world's largest producer of many food crops including rice, sweet potatoes, sorghum, soybeans, millets, barley, peanuts, and tea. Of the 124 million hectares of rice land in Asia, about 35 million hectares of rice were planted in China. The grain production in PRC was estimated at 255 and 140 million metric tons in 1974 and 1981, respectively (Kelman and Cook 1977; Anonymous 1982). About 80% of the rice is of indica varieties; they are developed for certain qualities including high yield, fast growth under high fertility, early maturity, and short stems. Since rice is the dominant crop in China, pests are considered as important production-limiting factors. Pest problems are more serious in the south than central and northern China. Of the total 114 species of rice pests damaging the rice during either the growing or post harvest seasons, the rice paddy borer, *Tryporyza incertulas* (Walker); purplish stem borer, *Sesamia inferens* Walker; rice stem borer, *Chilo suppressalis* Walker; green rice leafhopper, *Nephotettix cincticeps* Uhler; brown planthopper, *Nilaparvata lugens* Stål; white-backed planthopper, *Sogatella furcifera* Horvath; rice leaf roller, *Cnaphalocrocis medinalis* Guenee; rice skipper, *Parnara guttata* Bremer and Grey; rice weevil, *Echinocnemus squameus* Billb.; the planthopper, *Laodelphax striatellus* Fallen; rice leafminer, *Hydrellia griseola* Fallen; rice thrip, *Chloethrips oryzae* Williams, *Haplothrips aculeotus* Fab.; and rice green caterpillar, *Naranga aenescens* Moore; are the major ones (Anonymous 1977, 1978a, 1979a).

The use of chemical control was solely based on its effectiveness, safety and economy. The time to use insecticide was determined through the monitoring and forecasting system. The monitoring procedures and determining economic thresholds for various rice pests were described in recent reports (Anonymous 1977b; Chiang 1977b).

Cultural controls played an important part in pest control; they included the use of resistant varieties, removal of alternate hosts, planting trap crops, alternation of planting dates, and flooding of rice fields. Biological control agents such as *Trichogramma* spp., *Bacillus thuringiensis* Berliner, ducks, and frogs were used considerably for pest control. Light traps were used not only as a monitoring device, but also for insect control. In addition to the individual control measures, the integrated pest management program was most frequently used in crop protection (Anonymous 1977b, 1979b).

2. Cotton insects: China is the third largest cotton producing nation in the world with annual production at 11.1 million 480-lb. bales in 1981 (Anonymous 1982). The cotton producing areas include 19°–45° north latitudes and 75°–124° east longitudes (Anonymous 1979b) which cover Zhejiang, Hubei, Sichuan, Anhui, Jiangsu, Shanxi, Shaanxi, Hunan, Yunnan, Guizhou, Guangdong, Guangxi, Shangdong provinces (Kung 1975). Eight species of insect and one spider mite were recognized as important pests: cotton aphid, *Aphis gossypii* Glover; cutworms, *Agrotis ypsilon* Rott., *A. tokionis* Butler; green plant bugs, *Lygus lucorum* Meyer-Dur., *Adelphocoris suturalis* Jak.; pink bollworm, *Pectinophora gossypiella* Saunders; cotton bollworm, *Heliothis armigera* Hubner; cotton leafhopper, *Empoasca biguttula* Ishida; and two spotted spider mite, *Tetranychus urticae* Koch (Anonymous 1977b, 1979b). Monitoring and forecasting procedures for the above pests were widely used like those described for rice culture (Anonymous 1977b; Chiang 1977a, b). The measure used to control these pests included integrated pest control, good cultural practices, biological control, and chemical control (Anonymous 1977b, 1979a, b). The biological agents used in integrated control were *Chrysopa septempunctata* L. and five species of lady beetles for control of cotton aphids, *Dibrachys cavus* Walker for control of pink bollworm, *Trichogramma confusum* Viggiani, *T. dendrolimi* Matsumura as well as *B. thuringiensis* for control of cotton bollworm (Anonymous 1977b, 1979b).

3. Wheat insects: Wheat is the second largest grain crop in China, the production in 1981 was estimated at 54.2 million tons (Anonymous 1982). Nearly 120 species of wheat pests consisting of 46 families and 11 orders were reported (Anonymous 1977b). Among these, the wheat aphids, *Macrosiphum avenae* Fab.; *Rhopalosiphum maidis* Fitch; *Schizaphis graminum* Rondani; wheat armyworm, *Mythimna separata* Walker; wheat midges, *Sitodiplosis mosellana* Gehin and *Contarinia tritici* Kirby; wheat stem maggots, *Meromyza saltatrix* L. and *Oscinella pusilla* Meigen; wheat shoot mag-

got, *Nanna truncata* Fan.; grubs, *Hototrichia titanus* Reitt, *H. diomphalia* Bates, *H. serobiculata* Brenske, *Anomala cuprea* Hope; mole crickets, *Gryllotalpa africana* Palisot de Beauvois and *G. unispina* Saussure; wireworms, *Agriotes patrualis* Frivalsky, *Pleonomus canaliculatus* Faldermann and *Melanotus caudex* Lewis were considered as major pests (Anonymous 1972, 1974, 1979b). Monitoring and forecasting procedures for wheat aphids, wheat midges and army worms as well as underground pests were developed (Anonymous 1979b; Chiang 1977b), and the control measures for wheat insects were similar to those mentioned above.

4. Soybean insects: Soybean is grown throughout China with annual production at 7.9 million metric tons in 1981 (Anonymous 1982). The main production area is in the northeastern part of the country. A dozen species of insects are considered as major pests: soybean pod borer, *Leguminivora* (*Grapholitha*) *glycinivorella* Matsumura; soybean borer, *Maruca testulalis* Geyer; pea-pod borer, *Etiella zinckenella* Treitschke; soybean leafroller, *Heaylepta indicata* Fah.; bean hawk moth, *Clanis bilineata* Walker; soybean tussock moth, *Dasychira locuple* Walker; bean blister beetle, *Epicauta gorhami* Marseul; scarabaeid beetles, *Holotrichia gebleri* Faldermann, *H. diomphala* Bates, *Anomala corpulenta* Motsch, and *Maladera orientalis* Motsch; bean shoot aphid, *Aphis craccivora* Koch; bean leafroller, *Matsumuraeses phaseoli* Matsumura; bean weevil, *Xylinophorus mongolicus* Faust (Anonymous 1977b, 1979b). Control measures for the pod borer are: cultural control, resistant variety, chemical control, and biological control (Anonymous 1979b). For controlling other lepidopterous pests, the most commonly used methods are light traps, chemical control, cultural control and biological control (Anonymous 1977b, 1979b).

5. Other crops: Important pests of citrus fruits, deciduous fruits, vegetables, stored products and structures, man and animals and their control methods were discussed in detail by earlier reports (Anonymous 1977b, 1979b; Guyer 1977; Williams 1979).

Other achievements in applied entomology during this period are listed below.

1) Insecticide and its use: Scientists in PRC were very concerned about the undesirable side effects of various pesticides on human health and the environment. Therefore the emphasis of pest control was placed on integrated pest control in 1970's. Insecticides were carefully chosen and used only if justified. Mostly pesticides were used as a part of integrated pest management program. In this period, the consideration was given to the production of highly effective insecticides of low toxicity, nonpersistance, and low cost. Many organophosphorus insecticides were produced industrially. The most commonly used were trichlorfon, dichlorvos, dimethoate, phosmet, fenitrothion, phosphamidon, and malathion. Trichlorfon was used against the cotton pink bollworm, bollworm, rice planthopper and thrips,

and cabbage worms. Dichlorvos was used to control soybean pod borer, cabbage root maggot, cotton pink bollworm, cotton aphid, and other species of aphids, housefly, mosquito, and citrus longicorn beetles. Dimethoate was used for control of the citrus leafminer, leafrollers, mites, rice greenleafhopper, rice thrips, rice paddy borer, and cotton aphid. Phosmet was used to control the tea scale and citrus leafminer. Fenitrothion was used for rice paddy borer, rice leafhopper and planthopper (Anonymous 1977b, 1979b; Guyer 1977).

2) Biological control agent and its use: It was the government policy that all research must be directly applied to the real needs of people. Biological control fits very well in this concept and has received substantial support from the government. It has become the main feature of the integrated pest management program. The most widely researched and used biological control agents included *Trichogramma* spp., *Anastatus* sp., *Rodolia* spp., *Dibrachys cavus, Chrysopa* spp., *Bacillus thuringiensis* and *Beauveria bassiana.* By 1974, a total of 12 species of *Trichogramma* was reported in China including *T. australicum* Girault, *T. closterae* Pang et Chen, *T. dendrolimi* Matsumura, *T. evanescens* Westwood, *T. euproctidis* Girault, *T. ivelae* Pang et Chen, *T. japonicum* Ashmead (Anonymous 1978b), *T. leucaniae* Pang et Chen, *T. lingulatum* Pang et Chen, *T. ostriniae* Pang et Chen, *T. raoi* Nagaraja, and *T. sericini* Pang et Chen. Among these, only four species were widely used in 26 provinces and regions of PRC, they included *T. confusum* Riggiani (=*T. australicum*), *T. dendrolimi, T. japonicum* and *T. ostriniae* for control of such pests as *Ostrinia furnacalis* Guenee, *Chilo sacchariphagas* Bojer, *C. infuscatellus* Snellen, *Argyroploce schistaceana* Snellen, *Dendrolimus* spp. and *Heliothis armigera* Hb. with parasitization 70–80% (Anonymous 1978b, 1979b; Guyer 1977). *Anastatus* sp. was first used to control litchi stinkbug, *Tessaratoma papillosa* Drury in 1960's. It was reported that the parasitization could reach to 80–90% (Anonymous 1979b; Huang et al. 1974). Their use has been extended to another 11 species of lepidopterous insects and the eggs of several species of Hemiptera and Lepidoptera (Anonymous 1978b). *Dibrachys cavus* was successfully used for control of the overwintering population of the pink bollworm, *Pectinophora gossypiella* Saunders with parasitization over 80%. Four species of *Chrysopa* (*C. septempunctata* Wesmael, *C. sinica* Tjeder, *C. carnea* Stephens, *C. boninensis* Okamoto) were commonly used for control of *Aphis gossypii* Glover, *Tetranychus urticae* Koch, and the egg stage of *Heliothis armigera* and *Ostrinia furnacalis* (Anonymous 1979b).

The establishment of the introduced *Rodolia cardinalis* Mulsant in southern China had effectively controlled the cottony cushion scale, *Icerya purchasi* Moskell in the citrus groves. Another species of lady beetles *R. rufopilosa* Mulsant was also successfully used for control of *I. purchasi* in south China (Anonymous 1979b).

In the decade of 1966–1976, a total of 17 varieties of *Bacillus thuringiensis* Berliner including 12 distinct serotypes was isolated and characterized by the researchers at the Institute of Zoology, Academia Sinica in Beijing (Guyer 1977). The bacteria were mainly used to control the immatures of Lepidoptera. There were more than 70 pest species listed with variable results ranging from 30 to 100% kill. They were effectively used against such insects as *Cnaphalocrocis medinalis* Guen, *Paranara guttata* Br., *Tryporyza incertulas* Walk., *Plutella xylostella* (L.), *Artogeia rapae* (L.), *Ostrinia furnacalis* Guenee, *Dendrolimus punctatus* and *Heliothis armigera* Hubn. (Anonymous 1979b). During the period of 1973–1977, about 1,100 metric tons of microbial materials were used on about 12,800 hectares of cotton (Guyer 1977).

The use of *Beauveria bassiana* Vuill as a biological control agent was introduced in 1971, in four years it was expanded to nearly 57,720 hectares (Guyer 1977). This agent was especially effective against European corn borer, *O. furnacalis* in the field with 80–90% kill (Hsiu et al. 1973). The granular preparations of *Beauveria* were often used in combination with B. t., Trichogramma and/or chemicals in the integrated control programs.

3) Integrated pest management: The practice of integrated pest control (IPC) or integrated pest management (IPM) began in the 1950's in China. It became intensified and popularized during the Cultural Revolution as it was in line with the teaching of Chairman Mao who advocated that man conquer nature. Thus IPM received top priority and strong governmental support. The plant protection systems in PRC were largely based on IPC techniques. Several integrated approaches were used in this highly successful plant protection system. First, the scientists in PRC developed an efficient monitoring and forecasting system which was set up at four levels including provincial, county, commune and brigade. The provincial forecasting center operated by the Academy studied the population dynamics, economic damage thresholds of the pests, and the impact on natural enemy. All substations reported to the provincial center. The county forecasting station determined the time of occurrence of the pests, and advised the commune and brigade what and when to carry out control operations. The commune forecasting station operated at the farm level that consists of 5 to 15 brigade forecasting stations. The commune forecasting station monitored the start of insect activities in the spring as determined by light-trap catches, or monitored the insect populations at the overwintering sites. The brigade forecasting station monitored the target fields and relayed information to the commune (Chiang 1977b). The system served as a guide to timing chemical applications. The insecticides were only used if proved economical, effective and safe. Secondly, cultural control is considered of vital importance in Chinese plant protection system which emphasized prevention. This practice emphasized the reduction in pest populations during the period between two crops. The application of the biological and ecological information of the pest is essential

in this approach. There were several measures commonly used in the cultural control including the use of light-traps for monitoring and mass trapping, crop rotation, sanitation, regulation of planting and harvesting dates, the use of a trap crop and bait trap. Thirdly, biological control was used successfully and widely among pests of many crops including forest trees. This approach is ranked second after cultural control at the production level. The detailed biological control elements were described in the aforementioned sections.

Other methods of insect control such as the use of resistant variety, sex pheromones, hormones and various insect traps were also used to a considerable extent in the integrated management schemes during the Cultural Revolution period. For details readers should refer to the earlier publications (Anonymous 1977b, 1979b; Guyer 1977).

III. Current Educational and Research Organizations in PRC

Since 1976, drastic shifts in policy have occurred. The new ideology emphasized the four modernizations. The development of education and research in science and technology became the national goal. New policies are quickly implemented at every level.

A. Institutes of Higher Education

Currently PRC is restoring many higher institutions that were closed down during the Cultural Revolution period, and establishing new institutions. The number of institutions of higher learning is about 600 as compared to 430 in 1966. The secondary schools and colleges and universities are divided into "key institutions" and "non-key institutions." The former are designated as priority institutions for development and receive generous appropriation of funds and attention, as well as enjoying higher prestige. They are run by the Ministry of Education (MOE), the Ministry of Agriculture (MOA) or the Ministry of Forestry (MOF). Generally speaking, the brightest and best of the freshmen will go to key institutions. A total of 94 colleges and universities has been designated as "key" institutions. A list of them which offer courses in biological sciences or entomology is given in Table 1.

The basic structure of higher education in PRC has not changed much since the early 1950's when China patterned herself after the USSR. Most Chinese institutions of higher education remain highly specialized in certain fields.

1) Comprehensive universities: About 30 institutions of higher education are in this category whose curricula include both basic and applied sciences and the liberal arts. A number of well known institutions is listed in Table 1.

2) Agricultural colleges and universities: As mentioned before, basically

Table 1. Key universities and agricultural institutions in PRC.

Name[a]	Governing[b] body	Characterisitic
*Anhui Agricultural College	MOA	Agricultural
*Beijing Agricultural College	Beijing City	Agricultural
Beijing Agricultural University	MOA	Comprehensive
Beijing Forestry College	MOF	Forestry
Beijing Normal College	MOE	Comprehensive
Beijing University	MOE	Comprehensive
Central China Agricultural College	MOA	Agricultural
Central China University	MOE	Agricultural
Chinese People's University	MOE	Comprehensive
Chonqing University	MOE	Comprehensive
Fudan University	MOE	Comprehensive
*Fujian Agricultural College	PG	Agricultural
Gansu Agricultural University	PG	Agricultural
*Guangxi Agricultural College	PG	Agricultural
*Guizhou Agricultural College	PG	Agricultural
*Hebei Agricultural University	PG	Agricultural
*Henan Agricultural College	PG	Agricultural
*Hunan Agricultural College	PG	Agricultural
*Hunan University	MOE	Comprehensive
*Jiangsu Agricultural College	PG	Agricultural
Jianxi Agricultural University	MOA	Agricultural
*Jilin Agricultural College	MOA	Agricultural
Jilin University	MOE	Comprehensive
Jinan University	MOE	Comprehensive
Lanzhou University	MOE	Comprehensive
*Liaoning University	MOE	Comprehensive
Nanjing Agricultural College	MOA	Agricultural
Nanjing Forest Industry College	MOF	Forestry
Nanjing University	MOE	Comprehensive
Nankai University	MOE	Comprehensive
*Nei Monggol Agricultural College	MOA	Agricultural and Animal Husbandry
Nei Monggol University	MOE	Comprehensive
*Ningxia Agricultural College	MOA	Agricultural
Northwest University	MOE	Comprehensive
Northwestern College of Agriculture	MOA	Agricultural
*Qinghai Industrial & Agricultural College	MOA	Agricultural
Qinghua University	MOE	Comprehensive
*Shangdong Agricultural College	PG	Agricultural
Shangdong University	MOE	Comprehensive
Shanghai Agricultural College	Shanghai City	Agricultural
Shanghai Normal University	MOE	Comprehensive
*Shanxi Agricultural University	PG	Agricultural
*Shenyang Agricultural College	PG	Agricultural
*Sichuan Agricultural College	PG	Agricultural
Sichuan University	MOE	Comprehensive
South China Agricultural College	MOA	Agricultural

Table 1. Continued.

Name[a]	Governing[b] body	Characteristic
*Southwestern Agricultural College	MOA	Agricultural
Southwest University	MOA	Agricultural
Tianjin University	MOE	Comprehensive
Tongji University	MOE	Comprehensive
Wuhan University	MOE	Comprehensive
Xiamen University	MOE	Comprehensive
Xian Jiaotong University	MOE	Comprehensive
Xiangtan University	MOE	Comprehensive
*Xinjiang Bayi Agricultural College	Autonomous Region	Agricultural
Xinjiang University	MOE	Comprehensive
*Xinjiang Shihetze Agricultural College	MOA	Agricultural
Yenan University	MOE	Comprehensive
Yunnan Forestry College	MOF	Forestry
Yunnan University	MOE	Comprehensive
*Zhejiang Agricultural University	PG	Agricultural
Zhejiang University	CAS	Comprehensive
Zhongshan University	MOE	Comprehensive

[a] * = non-key institutions; without * = key institution.
[b] MOE = Ministry of Education; MOA = Ministry of Agriculture; MOF = Ministry of Forestry; CAS = Chinese Academy of Sciences; PG = Provincial Government.

the PRC has an agricultural economy. Virtually all cultivable land is used for crops, and the intensive cultural techniques have already secured high yields. To increase the yields any further requires better technology. Thus, agricultural colleges and universities play an important role in this effort. There are approximately 90 agricultural schools throughout China, and they are mostly operated by the Ministry of Agriculture, the Ministry of Agricultural Machinery, or Provincial Bureaus of Agriculture. Nearly all provinces, autonomous regions and special municipalities have one agricultural college with the exception of Xizang autonomous region (see map). A list of well known agricultural colleges which deal with teaching and research in plant protection is given in Table 1.

3) Other specialized institutions of higher education: Other institutions of higher education can be categorized based on the nature of their curriculum. They include: (a) polytechnic colleges and universities, (b) normal colleges, (c) medical colleges, (d) science universities, (e) machine-building colleges, (f) shipbuilding colleges, (g) aeronautics colleges, (h) electronic and telecommunication colleges, (i) light industry colleges, (j) construction colleges, (k) transportation colleges, (l) mining and metallurgy colleges, (m) chemical and petroleum engineering colleges, (n) electric power college, (o) geology col-

leges, (p) meteorology colleges, (q) oceanography colleges, (r) other non-technical colleges.

B. Institutes of Research

Currently PRC is attempting to upgrade the levels of professional researchers as well as training future generations of professionals. Entomological research in PRC takes place under the auspices of the Chinese Academy of Sciences, and the Ministry of Agriculture. The former is in charge of formulating science policy, conducting basic research, and running several universities. Therefore, it is considered as a prestigious organization. There are over 100 research institutes, five universities, and four libraries under the jurisdiction of CAS. The primary emphasis of research institutes is in basic research. However, CAS is also involved in teaching at its five universities and training researchers at the graduate levels. The research institutes of CAS dealing with agricultural production or plant protection are listed as follows: In Beijing: Institute of Chemistry, Institute of Microbiology, Institute of Genetics, Institute of Zoology, Institute of Botany; In Shanghai: Institute of Biochemistry, Institute of Cell Biology, Institute of Plant Physiology, Institute of Entomology; In Sichuan Province: Institute of Biology;

In Yunnan Province: Institute of Zoology, Institute of Botany, Institute of Tropical Plants; In Guangdong Province: Institute of Botany; In Liaoning Province: Institute of Forestry and Pedology; In Hubei Province: Institute of Virology, Institute of Botany; In Xinjiang Autonomous Region: Institute of Chemistry, Institute of Biology, Pedology and Deserts; In Hebei Province: Luancheng Institute of Agriculture Modernization; In Heilungjiang Province: Institute of Agriculture Modernization; In Hunan Province: Taoyuan Institute of Agriculture Modernization. The universities administered by CAS are: In Anhui Province: University of Science and Technology of China; In Beijing: School of Graduate Study, University of Science and Technology of China; In Zhejiang Province: Zhejiang University; In Sichuan Province: Chengdu University of Science and Technology; In Heilungjiang Province: Harbin University of Science and Technology.

The Ministry of Agriculture manages its own institutes numbering several hundred. The primary emphasis is conducting applied research. In general the research institutes are under the jurisdiction of the provincial Academy of Agriculture. The academies coordinate the activities of their subordinate research institutes. Nearly every province or autonomous region has a provincial academy of agriculture.

C. Undergraduate and Graduate Education

Currently, the undergraduate curriculum is a four-year curriculum with the requirement of 140 credit hours. However, some universities and colleges have reinstated a five-year curriculum. The students are selected almost exclusively on the basis of a nationally standardized entrance examination. The entrance examination is held simultaneously for a 3-day period at the various testing centers throughout the nation. As of July 1982, all participants are required to take three basic subjects including Chinese, politics, and mathematics. In addition, students majoring in science and technology are required to take tests in biology, physics and chemistry, and those majoring in social science and humanities are tested in history and geography. The third test is the foreign language test, all examinees are given one of the seven choices: English, French, German, Japanese, Russian, Spanish or Arabic. The total points that the examinee majoring in science scores out of 600 possible points determines the outcome. However, the score on the foreign language test is not counted in calculating the overall point total, it is only used for considering student's candidacy by the prospective college (Barendsen 1979; Hsu 1979). The passing score varies in different areas. The acceptance total score for the resident student in Beijing area for 1980 was 370 points at 500 possible points, where for students in other provinces the cutoff total score was 348 points. Because of limited capabilities and short resources, it is estimated that among the 12 million high school graduates, only about 300,000 students are able to enter the colleges. Current total undergraduate enrollments in China stand at about 1.2 to 1.5 million. The goal set for 1985 is at 3 million (Abelson 1979). Graduate enrollments will be increased to 200,000 by 1990. The faculty and student ratio is at 1:3. This enables close contact between students and professors. Thus the relationship, as traditional in China, becomes lifelong.

During the four years, all undergraduates majoring in plant protection are required to take courses in: foreign language, general physics, organic chemistry, inorganic chemistry, advanced mathematics, general botany, plant physiology, agricultural meteorology, philosophy, plant protection, political economics, plant pathology, agricultural plant pathology, general entomology, agricultural entomology, plant immunology, monitoring and forecasting, biostatistics, mycology, plant bacteriology, plant virology, research techniques, plant biochemistry, insect taxonomy, insect ecology, integrated pest control, insect morphology, plant quarantine, insect physiology and insect toxicology. The following courses are offered by some colleges: crop cultivation, cultivation techniques, plant breeding, soil and fertilizer, fruit tree cultivation, vegetable production, agricultural machinery, agricultural economics. The equipment and facilities in teaching laboratories and the libraries are generally adequate in most institutions. More expansion and improvement are underway. Some newly restored teaching laboratories have been equal to or superior to comparable institutions in the U.S.

Graduate programs were restored in the fall of 1978. Similarly, recruitment into graduate programs is on the basis of both preliminary and subject matter examinations. The former consists of four basic tests in politics, foreign language, a basic subject, and one of the specialized subjects. The preliminary examination is a nationally standardized test. The latter consists of foreign language, basic subject, specialized subject. The last tests are conducted by each graduate school. As a result, only one in six college graduates is able to pass the test. From this test program it is apparent that the leaders in PRC realize the importance of foreign languages as a tool in learning advanced science and technology. In 1979 approximately 19,000 graduate students selected from the 200,000 college graduates were enrolled in over 200 colleges and universities as well as 150 research institutes of the CAS and CAAS.

The graduate curriculum ranges from 2 to 4 years depending on various institutions. Because this program is still at its infant stage, it is somewhat flexible, with more emphasis placed on research, rather than the research and course work normally required in other countries.

Since the restoration of graduate study programs in 1978, the leaders in PRC also have realized the need to award the academic degrees which would help stimulate national interest in scientific research, raise academic standards, and facilitate international academic exchanges. Subsequently, the regulations governing the award of three academic degrees (Bachelor, Master and Doctor) were approved by the National People's Congress in February 1979. The measures further provide the State Council of PRC with a vehicle to establish an academic degrees committee. The bachelor degree is awarded by 458 colleges and universities authorized by the State Council, whereas master and doctor degrees are awarded by the academic degrees committee. Candidates enrolled in the institutions of higher learning and research institutes as well as those who can pass the qualifying examination and satisfy examiners in an oral examination or a written thesis are eligible for postgraduate degrees. The same regulations also apply to foreign students studying in PRC. Provisions are also made to award honorary degrees to outstanding scholars residing at home and abroad.

In 1980, the State Council approved the designation of the additional universities as key national institutions of higher education: (Northwest University, Southwest University, Central China University, South China University and Shenyang University), serving the needs of all regions. It is worth noting that these newest key universities have formally separated the Department of Plant Protection into a Department of Entomology and a Department of Plant Pathology. They are charged with the responsibility of training college faculty and researchers for the respective regions, whereas other colleges of agriculture still retain the Department of Plant Protection with the responsibility of training plant protection specialists in the fields.

The impact of the Cultural Revolution on China's education is profound. China not only has lost a generation of college graduates, but also a generation of students at other levels as well. Therefore, the tasks of modernization of a large educational system are enormous and complex. Currently, PRC produces about 200,000 college graduates per year. The newly initiated educational exchange programs with the Western countries, and the government funded overseas study programs are of current priority to the Chinese government. From January 1978 to November 1979, a total of 2,230 students and scholars was sent overseas including 1,600 researchers and scholars, 180 graduate students, and 450 undergraduates. Among these, 1,800 students were majoring in natural sciences, the rest in social study and linguistics. There were 500 individuals in the U.S., 500 in U.K., 200 in France, 200 in F.R. Germany and 100 in Japan. China's aim in sending students and scholars overseas for 1980 was 10–20,000. It was estimated that about 6,000 Chinese students and scholars were studying at the U.S. universities at the end of 1981.

Conclusions

China has an ancient history of science and civilization. Unfortunately, China has been repeatedly subjected to socio-economical, political, and intellectual chaos and revolutions in her search for accommodation with the modern world since the turn of the 19th Century. The process of transforming a traditionally agricultural society into a modern, industrial state has not been an easy one. After 1948, a decade of remarkable progress had been made on the unification of the country, self-sufficiency, fostering education and research. In the last two decades there have been advances, but progress has been variable. This was due in large part to repeated changes in ideology. One of the ideological changes with profound effect on education and research was the Cultural Revolution. As a result, China has lost a generation of educators and researchers. To implement the four modernizations and to make up for ground lost during this period are enormous and complex tasks which would require a vast infusion of foreign technical assistance and the creation of domestically exceptional capabilities. Hence, there are ample opportunities for foreign scientists to cooperate with Chinese counterparts.

During the Cultural Revolution, basic research in plant protection was greatly disrupted, but some applied research flourished. In some aspects of plant protection, the Chinese are indeed ahead of Western nations and are probably in a better position than any other nation to provide alternatives to chemical control of a number of agricultural pests. Many common pests in the PRC have been effectively managed and controlled by the use of integrated pest management measures involving cultural control, biological control, as well as some chemical methods. The success of IPM programs in China is attributed to the widespread enthusiasm for IPM shared by the farmers, scientists and administrators, and, to the application of the ecological principles essential to its development. The insect control measures developed in China are simple, effective and economical. Therefore, they could be used in other parts of the world where crop production and protection are carried out mostly by small farmers with little modern technology.

To increase grain production in meeting the need of population growth in China and to boost its already high per unit area yields pose a great challenge to Chinese scientists. Basic research and modern technology will undoubtedly play an important role in developing modern plant protection techniques in the years ahead. However, Chinese scientists should be aware of the impact of modern technology on the future plant production and protection, such example as the impact of the green revolution on plant protection in tropical and subtropical areas (Smith 1972). Also, they should be aware of the fact that once truly committed to modernization, they will face no end of changes, pressures and socio-economic problems. China is known to be well endowed with many important minerals and energy resources. Oil reserves are estimated at least three times as large as those of the U.S. It has tremendous resources of talented, industrious and moral people. It is to be hoped that their national goals will soon be realized.

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